

WE CLAIM:

1. A method for growing thin films onto a surface of a substrate by exposing the substrate to alternatively repeated surface reactions of vapor-phase reactants, the method comprising the steps of:

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providing a first reactant source;

providing an inactive gas source;

feeding a first reactant from the first reactant source in the form of repeated alternating pulses to a reaction chamber via a first conduit;

allowing the first reactant to react with the surface of the substrate in the reaction chamber;

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feeding inactive gas from the inactive gas source into the first conduit via a second conduit that is connected to the first conduit at a first connection point so as to create a gas phase barrier between the repeated alternating pulses of the first reactant entering the reaction chamber; and

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withdrawing the inactive gas from said first conduit via a third conduit connected to the first conduit at a second connection point.

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2. The method of Claim 1, further comprising the step of providing the second connection point upstream of the first connection point so that, at least for some length of the first conduit, the inactive gas fed into the first conduit flows upstream towards the first reactant source.

3. The method according to Claim 1, wherein the step of providing a first reactant source comprises vaporizing the first reactant.

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4. The method according to Claim 3, wherein the step of providing a first reactant source further comprising maintaining the first reactant source at least at a vaporizing temperature of the first reactant.

5. The method of Claim 1, wherein the step of providing a first reactant source comprises freeing solid reactant from solid particles located within the first reactant source.

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6. The method of Claim 1, wherein the step of providing a first reactant source comprises freeing liquid reactant from a suspended liquid in the first reactant source.

7. The method of Claim 1, further comprising the steps of providing a purifier and passing the first reactant through the purifier before transferring the first reactant into the reaction chamber.

5 8. The method of Claim 7, wherein the purifier is a filter comprising at least one of a ceramic molecular sieve and an electrostatic filter capable of separating one of at least dispersed liquid, solid droplets, particles and molecules of a minimum molecular size from the reactant gas flow.

10 9. The method according Claim 7, wherein the purifier is an active purifier comprising functional groups capable of reacting with components present in the reactant gas flow.

10. The method of Claim 7, wherein the step of providing a purifier further includes providing the purifier along the first conduit between the second connection point and the first reactant source.

15 11. The method of Claim 10, further including only passing the first reactant over the purifier in a signal direction.

12. The method according to Claims 10, further comprising the step of forming the gas phase barrier between the purifier and the reaction chamber.

13. The method according to Claim 1, further comprising providing the second connection point between the first connection point and the first reactant source.

20 14. The method of Claim 1, further comprising the step of maintaining the third conduit at a temperature at least equal to a condensation temperature of the first reactant.

25 15. The method according to Claim 1, further comprising the step of maintaining the second conduit at a temperature no greater than a reaction temperature of the reaction chamber.

16. The method according to Claim 1, wherein the third conduit is an open gas flow channel.

17. The method according to Claim 1, wherein the third conduit does not include valves.

30 18. The method according to Claim 1, wherein the first conduit does not include valves.

19. The method according to Claim 1, further comprising the steps of providing an outlet conduit for withdrawing unreacted reactants from the reaction chamber and connecting the third conduit to the outlet conduit.

5 20. The method according to Claim 1, further comprising the steps of providing an outlet conduit for withdrawing unreacted reactants from the reaction chamber and connecting the third conduit to a separate outlet conduit.

21. The method according to Claim 1, further comprising the steps of connecting a second inactive gas source to an inlet of the first reactant source and using inactive gas from the second inactive gas source as a carrier gas for the first reactant.

10 22. The method according to Claim 1, further comprising the steps of connecting the inactive gas source to an inlet of the first reactant source and using inactive gas from the second inactive gas source as a carrier gas for the first reactant.

15 23. The method according to Claim 1, further comprising the steps of draining substantially all of the first reactant from the reactant source through the third conduit to between the repeated alternating pulse of the first reactant.

24. The method according to Claim 1, further comprising the steps of providing a condensation vessel and connecting the condensation vessel to the third conduit and condensing vaporized reactant residues in the condensation vessel.

20 25. The method according to Claim 1, further comprising connecting a second inactive gas source to the third conduit via a fourth conduit and feeding inactive gas into the third conduit.

26. The method according to Claim 25, further comprising using the inactive gas fed into the third conduit via the fourth conduit to reduce an amount of gas withdrawn from the first conduit.

25 27. The method according to Claim 1, further comprising connecting the inactive gas source to the third conduit via a fourth conduit and feeding inactive gas into the third conduit.

30 28. The method according to Claim 27, further comprising using the inactive gas fed into the third conduit via the fourth conduit to reduce an amount of gas withdrawn from the first conduit.

29. The method according to Claim 28, further comprising feeding the inactive gas into the third conduit via the fourth conduit when the first reactant is being fed into the reaction chamber. wherein the inactive gas is fed during pulsing of the reactant.

5 30. The method according to Claim 1, further comprising connecting the inactive gas source to the third conduit via a fourth conduit upstream of a flow restrictor and feeding inactive gas into the third conduit.

10 31. The method according to Claim 1, further comprising feeding inactive gas into the reaction chamber in-between the repeated alternating pulses of the first reactant.

32. The method according to Claim 1, further comprising the steps of alternately, with respect to the first reactant, transferring a second reactant into the reaction chamber and allowing the second reactant to react with the surface of the substrate in the reaction chamber.

15 33. The method according to Claim 1, further comprising the steps of:

providing a second reactant source;

transferring a second reactant from the second reactant source to the reaction chamber via a fourth conduit;

alternately, with respect to the first reactant, allowing the second reactant to react with the surface of the substrate in the reaction chamber;

20 feeding inactive gas from the inactive gas source into the fourth conduit via a fifth conduit that is connected to the fourth conduit at a third connection point so as to create a second gas phase barrier between repeated alternating pulses of the second reactant entering the reaction chamber; and

25 withdrawing the inactive gas from said fourth conduit via a sixth conduit connected to the fourth conduit at a fourth connection point.

34. An apparatus for growing thin films onto a surface of a substrate by exposing the substrate to alternatively repeated surface reactions of vapor-phase reactants, the method comprising:

30 a first reactant source;

an inactive gas source;

a reaction chamber that provides a space for a first reactant from the first reactant source to react with the surface of the substrate;

a first conduit that connects the first reactant source to the reaction chamber;

5 a second conduit that connects the first conduit to the inactive gas source at a first connection point; and

a third conduit that connects the first conduit to an outlet at a second connection point.

10 35. The apparatus of Claim 34, wherein the second connection point is located between the first connection point and the first reactant source.

36. The apparatus according to Claim 34, wherein the first reactant source is maintained at least at a vaporizing temperature of the first reactant.

37. The apparatus of Claim 34, wherein the first reactant source comprises solid reactant from solid particles.

15 38. The apparatus of Claim 34, wherein the first reaction source comprises liquid reactant from a suspended liquid.

39. The apparatus of Claim 34, further comprising a purifier located along the first conduit between the first reaction source and the reaction chamber.

20 40. The apparatus according to any of Claims 39, wherein the purifier is a filter comprising at least one of a ceramic molecular sieve and an electrostatic filter capable of separating one of at least dispersed liquid, solid droplets, particles and molecules of a minimum molecular size from the reactant gas flow.

25 41. The apparatus according to any of Claims 39, wherein the purifier is an active purifier comprising functional groups capable of reacting with components present in the reactant gas flow.

42. The apparatus of Claim 39, wherein the purifier is located between the first connection point and the first reaction source.

43. The apparatus of Claim 42, wherein the second connection point is located between the first connection point and the first reactant source.

30 44. The apparatus of Claim 43, wherein the purifier is located between the second connection point and the first reactant source.

45. The apparatus of Claim 34, wherein the third conduit is maintained at a temperature equal to or higher than a condensation temperature of the first reactant.

46. The apparatus according to Claim 34, wherein the second conduit is maintained at a temperature no greater than a reaction temperature of the reaction chamber.

47. The apparatus according to Claim 34, wherein the third conduit is an open gas flow channel.

48. The apparatus according to Claim 34, wherein the third conduit does not include valves.

49. The apparatus according to Claim 34, wherein the first conduit does not include valves.

50. The apparatus according to Claim 34, further comprising the outlet is also connected to the reaction chamber.

51. The apparatus according to Claim 34, wherein the reaction chamber is connected to a separate outlet than the third conduit.

52. The apparatus according to Claim 34, further comprising a second inactive gas source and a fourth conduit that connects an inlet of the first reactant source to the second inactive gas source so as to provide carrier gas for the first reactant.

53. The apparatus according to Claim 34, further comprising a fourth conduit that connects the inactive gas source to an inlet of the first reactant source so as to provide a carrier gas for the first reactant.

54. The apparatus according to Claim 34, further comprising a condensation vessel that is connected to the third conduit.

55. The apparatus according to Claim 34, further comprising a second inactive gas source that is connected to the third conduit via a fourth conduit.

56. The apparatus according to Claim 34, further comprising a fourth conduit that connects the inactive gas source to the third conduit.

57. The apparatus according to Claim 56, wherein the fourth conduit is connected to the third conduit upstream of a flow restrictor.

58. The apparatus according to Claim 34, further comprising a second reactant source;

a fourth conduit that connects the second reactant source to the reaction chamber;

a fifth conduit that connects the inactive gas source to the fourth conduit at a third connection point; and a

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a sixth conduit that is connected to the fourth conduit and the outlet.

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